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(54) FASTENING DEVICES

(71) We, DELTA MATERIALS RESEARCH LIMITED, a British Company, of 1 Kingsway, London WC2B 6XF, do hereby declare this invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to fastening devices, particularly of the nut and screw type, comprising an externally threaded male member and a mating internally threaded nut.

It frequently occurs that when the nut and screw of a fastening device are left in mating engagement over a period of time, they become bonded together, due to rusting, corrosion or like effect. It is then difficult, and sometimes impossible, to separate the nut from the male member and release the fastening device. Equally, the nut may be impossible to release from the male member, if the nut has been screwed on with such force as to cause distortion of the threads.

An object of the present invention is to provide a design of fastening device, the components of which can be easily released, even if they have become bonded together.

The invention makes use of materials, which are usually metal alloys, and which have the characteristic of shape memory. A device made of such a material, which will be referred to hereinafter as "a shape memory effect material" has the property of being able to revert from a first shape at one temperature towards a different shape, when the temperature is sufficiently changed. The shape towards which the device reverts is one which the device was given previously, when at the different temperature. Shape memory effect materials are now well known in the literature, the best known metal alloys being nickel-titanium alloys, Cu-Zn-X alloys where X can be Al,Sn and Si and Cu-Al-Y alloys where Y can be Fe, Mn or Si. Such an alloy, if raised in temperature through a transition temperature range while stressed, will revert approximately to its previous shape if subsequently cooled to a temperature below the transition temperature range.

According to the present invention, a fastening device comprises an externally threaded male member and a mating internally threaded nut which is dimensioned normally to be received on, and to turn on, the male member at a temperature within an operating temperature range, at least one of the male member and nut being made of a shape memory effect material such that, on cooling from the operating temperature range, the engagement between the male member and the nut is loosened.

Thus, if for example the nut is made of shape memory effect material, that material may be selected so that the transition temperature range is below normal ambient temperatures. The nut can then be applied to the male member in the conventional manner; if bonding or excessive stiction occurs, the nut can be released by cooling it below the transition temperature range when expansion of the nut occurs. In that case, the "operating temperature range" is the range of ambient temperatures.

Where the nut is made of a shape memory effect material, it may be formed as a split nut which opens out in horseshoe form on being cooled. Particularly when the nut has no split, it may have passageways through it for the entry of a refrigerant.

The invention will be more readily understood by way of example from the following description of fastening devices in accordance therewith, reference being made to the accompanying drawings, in which

Figures 1A and 1B are axial sections through two forms of nut and screw fastening devices,

Figure 2 is an end view of a split nut,

Figure 3A is an end view of an modified form of fastener,

Figure 3B is a section on the line III-III of Figure 3A, and

Figure 4 shows in axial section a special tool for applying the refrigerant to a nut made of shape memory effect material.

Each of the fastening devices of Figures 1A and 1B comprises a bolt 12 which is externally threaded at 13, and a nut 14 with an internal, complementary and mating, thread. Figures 1A and 1B differ only in the form of the threads employed.

The nut 14 is made of a shape memory effect metal alloy, e.g. one of the alloys referred to above. The alloy selected and the method of manufacturing the nut 14 are such that at least the lowest point of the transition temperature range of the alloy is below the lowest ambient temperature likely to be experienced by the fastening device; preferably, the entire transition temperature range is below the lowest ambient temperature. Secondly, the nut 14, when at ambient temperature, is a tight fit upon the threads 13 of the bolt 12, so that it may be threaded on, and screwed off, the bolt 12. If, then, the temperature of the nut 14 is lowered below the transition temperature range, the nut progressively expands outwardly, its thread then having the form shown diagrammatically in chain line at 15, in which the nut is a loose fit on the bolt 12.

If the nut 14 should become bonded to the bolt 12 at ambient temperature, due to corrosion, the nut can be simply released by lowering its temperature, when the expansion of the nut causes the bond to break.

The bolt 12 may alternatively or additionally be made of shape memory effect metal alloy. In that case, the bolt is made in such a way that, at ambient temperature, it is a tight fit within the nut 14, but when reduced in temperature to below the transition temperature range it contracts, again to cause the nut to be a loose fit upon the bolt 12.

The nut may be a split nut, as illustrated in Figure 2 at 16. When the temperature is lowered, the nut opens into horeshoe shape to cause it again to be a loose fit on a threaded bolt (not shown). The form of nut shown in Figure 2 has particular application where acme or buttress threads are used, since those threads would not cause bursting of the split nut on tightening.

The temperature at which loosening of the nut occurs depends on the circumstances of use. Thus, where the fastener is to be used in the presence of water, the lowest point of the transition temperature range should be above the freezing point of water; then loosening can be brought about without water freezing in the threads. For example, the lowest point of the transition temperature range may be 6°C, in which case the ambient temperature at which the fastener operates may be within, and not above, the transition temperature range.

In the absence of water, it is preferred to have the entire transition temperature range below the range of likely ambient temperatures. Maximum tightening of the nut on the bolt then occurs at ambient temperature, while the nut can be loosened by reducing its temperature well below the freezing point of water, using for example frozen liquids or gases such as freon, and carbon dioxide.

In order to effect efficient cooling of the nut, and the bolt when the latter is made of shape memory effect material, holes or other passageways may be incorporated in the nut, as illustrated in Figures 3A and 3B. In those figures, the nut 14 is shown as having an entrance hole 17 leading to an inaternal annular groove 18. The refrigerant is introduced through hole 17 and, by virtue of the groove 18, comes into contact with a large surface area of the nut.

A special tool may be employed both to undo the nut and to concentrate coolant or refrigerant on to the appropriate area of the fastener. Such a tool is illustrated in Figure 4 as comprising a hollow tube 20, which is rotatably mounted in a carrier sleeve 21 integral with a nozzle 22 communicating with the interior of tube 20 by an opening 23. One end of the tube 20 is closed, while the other end is formed with threads which engage with threads 24 formed on the end of nut 14. A refrigerant is poured into the nozzle 22, so as to fill the tube 20 and contact the ends of bolt 12 and nut 14. When the fall in temperature has caused nut 14 to be loose on the bolt 12, the nut is unthreaded by rotation of the sleeve 20.

The component (the nut and/or the bolt) is given its required shape memory effect characteristic, by placing it under stress, and then cycling the temperature through the transition temperature range, or giving the component an extended heat treatment at a temperature above that range, again while under stress. Thus, to make the nut 14, the following steps may be employed:—

1. Make a nut blank from extruded or forged shape memory effect metal alloy.

2. Drill a small pilot hole for the screw thread.

3. Heat treat the blank to give it the required metallurgical structure for shape

memory.

4. Drill the pilot hole out to a diameter equal to the core diameter less about 3%.

5. Cool the blank to a temperature below the transition temperature range and then expand the pilot hole by 2% using a taper mandrel.

6. Heat the blank with the mandrel in place, thereby subjecting the blank to high stress.

7. Reduce the temperature of the blank below the transition temperature range and repeat the temperature cycle as necessary. Remove the mandrel.

8. Allow the blank to return to room temperature when it should have a bore equal to the core diameter less 1%.

9. Machine out the pilot hole to the exact required core diameter and machine the screw thread.

Similarly, an SME bolt may be made as follows:—

1. Make a bolt blank from extruded or forged stock.

2. Heat treat the blank to give it a metallurical structure required for shape memory.

3. Turn the blank to a diameter approximately 3% greater than the required diameter, over the threaded length.

4. Cool the blank to below the transition temperature range and compress the diameter by 2% using a tapered die.

5. Heat the blank to above the transition temperature range with the die in place, thereby subjecting the blank to high stress.

6. Cool the blank and die to below the transition temperature range and then subject them to further temperature cycles as required. Remove the die.

7. Allow the temperature to rise to room temperature and machine the blank to the required thread diameter and thread form, so that it is a close fit within the co-operating nut.

WHAT WE CLAIM IS:—

1. A fastening device comprising an externally threaded male member and a mating internally threaded nut which is dimensioned normally to be received on, and to turn on, the male member at a temperature within an operating temperature range, at least one of the male member and nut being made of a shape memory effect material such that, on cooling from the operating temperature range, the engagement between the male member and the nut is loosened.

2. A fastening device according to claim 1, in which the nut is a split nut which is made of a shape memory effect material and which opens out on cooling.

3. A fastening device according to claim 1, in which the nut is made of shape memory effect material and has passageways for the entry of a refrigerant.

4. A fastening device substantially as herein described with reference to the accompanying drawings.

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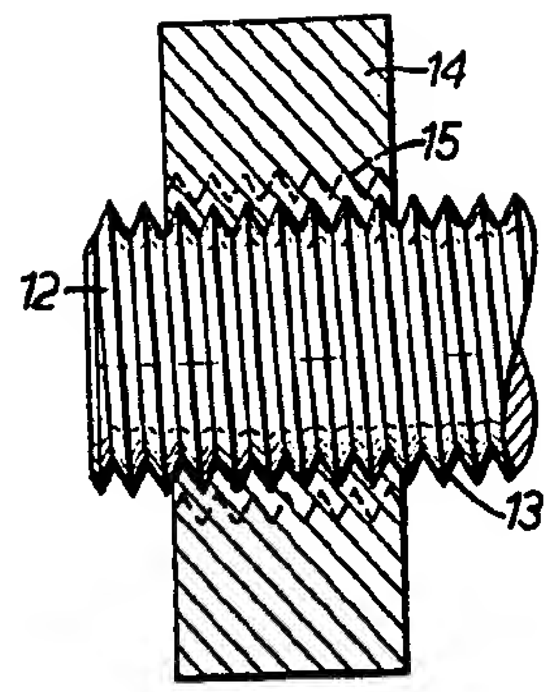

FIG. 1A.

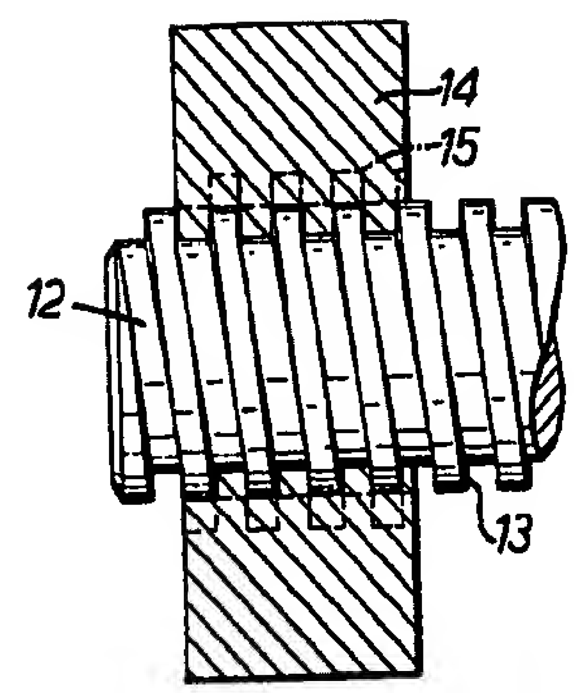

FIG. 1B.

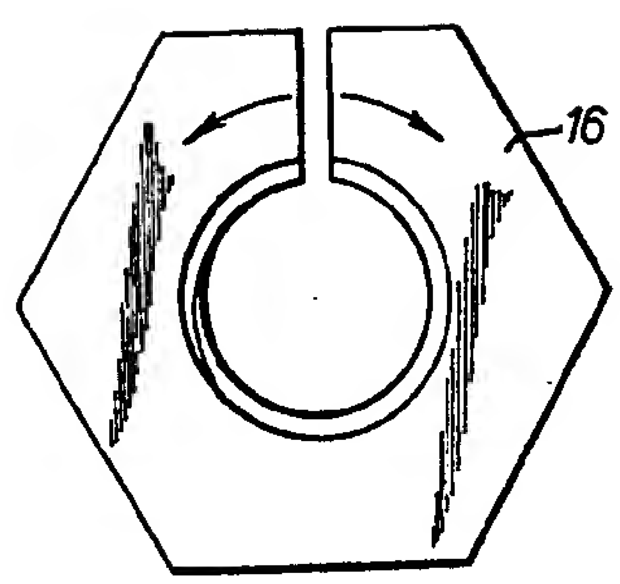

FIG. 2.

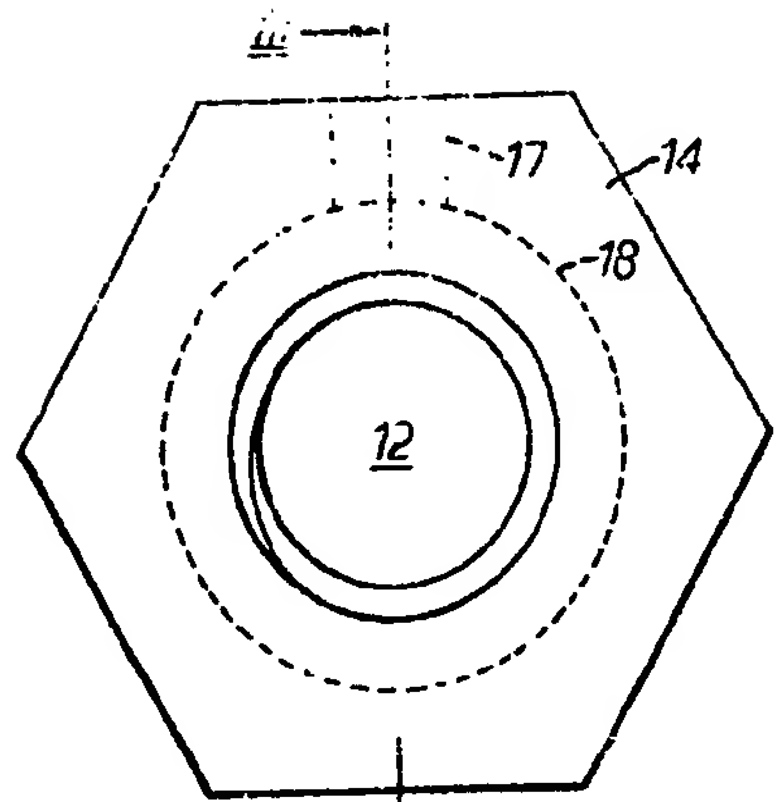

FIG. 3A.

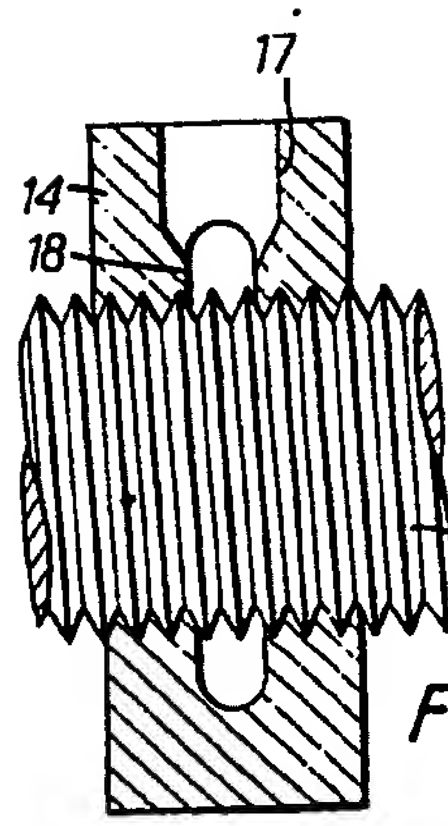

FIG. 3B.

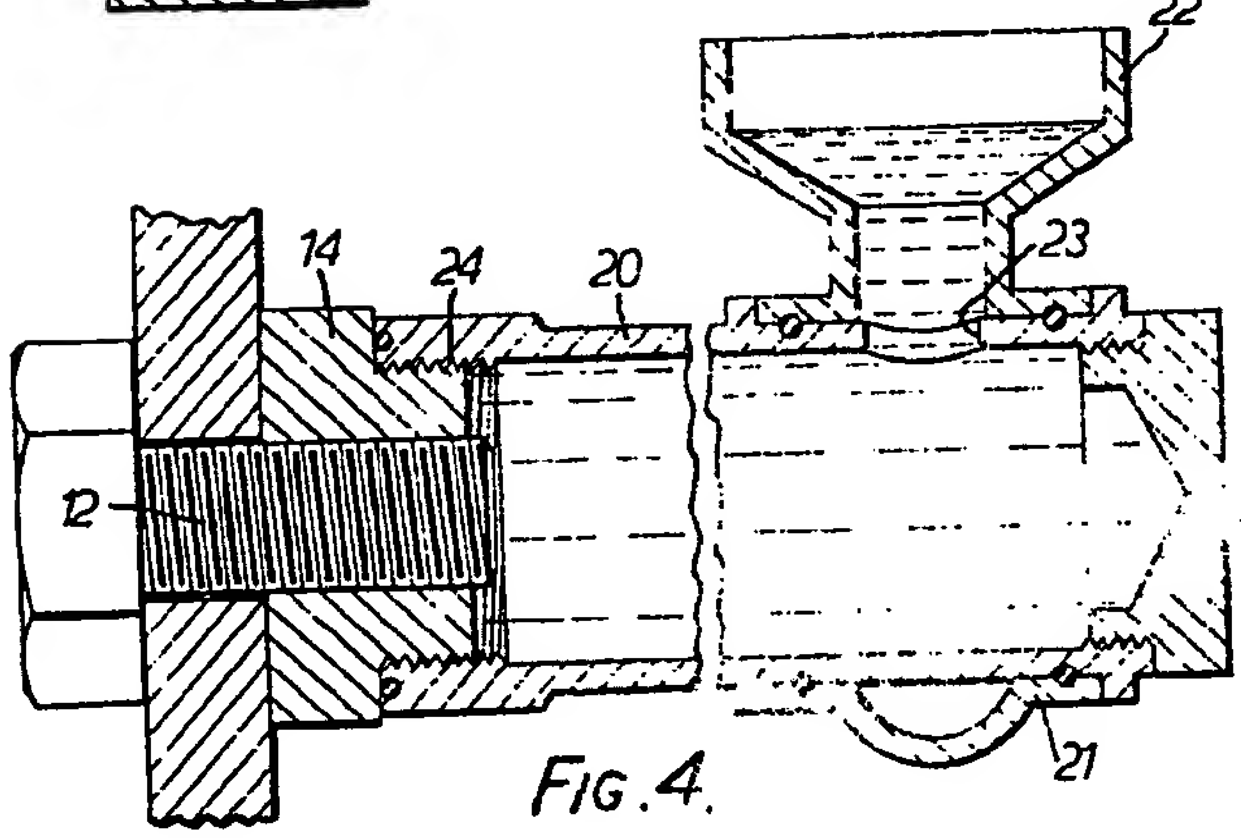

FIG. 4.